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**APPLICATION FOR UNITED STATES  
LETTERS PATENT**

**REACTOR AND METHOD FOR FLY STREAM GASIFICATION**

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## **BACKGROUND OF THE INVENTION**

### **1. Field of the Invention**

The invention relates to a reactor for the gasification of ash-free or low-ash fuels, residues and waste in a fly stream reactor, and to a method for operating the reactor.

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### **2. Description of the Related Art**

As used herein, "fuels, residues and waste" are intended to refer to those without or with only a low ash content, such as oils, tars, liquid fractions from the waste and recycling economy, such as used oils, PCB-containing oils, plastic fractions, residues and waste from the chemical industry, such as, for example, nitrogen-containing, sulfur-containing or halogen-containing hydrocarbons, hydrocarbon mixtures and also petroleum coke from crude oil processing.

In gas generating technology, the autothermic fly stream gasification of solid, liquid and gaseous fuels has been known for many years. In this context, the ratio of fuel to oxygen-containing gasifying agents is selected such that, for the sake of the quality of the synthesis gas, higher carbon compounds are split up completely into synthesis gas components, such as CO and H<sub>2</sub>, and the inorganic constituents are discharged as molten slag (J. Carl, P. Fritz, NOELL-KONVERSIONSVERFAHREN, EF-Verlag für Energie- und Umwelttechnik GmbH 1996, p. 33 and p. 73).

In this case, according to various systems introduced in the technology, gasifying gas and the molten inorganic fraction, for example slag, can be discharged or separated jointly

from the reaction space of the gasification apparatus, this being gathered from  
DE 19718131.7 A1.

For the internal delimitation of the contour of the reaction space of the  
gasification system, systems either provided with a refractory lining or cooled have been  
5 introduced and are known, for example, from DE 4446803 A1.

Gasification systems provided with a refractory lining have the advantage of low  
heat losses and therefore afford an energy-efficient conversion of the gasification substances  
supplied. Their use is concentrated on ash-free or low-ash gasification substances.

According to the prior art, gasification reactors are designed in such a way that  
10 one or more layers of refractory material for delimiting the reaction space, which has a  
temperature of 1000-1600°C, are arranged within a pressure casing for insulation and thermal  
protection. To protect the pressure casing against excessively high temperatures, a water jacket  
may be arranged inside or outside the latter.

If the water jacket is arranged inside the pressure casing in the way described by  
15 way of example in DE 198 29 385 C1, a considerable outlay in regulating terms is involved in  
causing the pressure in the water jacket to follow changes in pressure in the reaction space, such  
as occur particularly during start-up and run-down operations, in order to prevent destruction on  
account of too high a pressure difference. Moreover, the constraint to maintain a maximum  
pressure difference between the reaction space and the water jacket detracts from the possibility  
20 of regulating the temperature in the water jacket in such a way that the dew point of the moist  
gases of the reaction space is not reached on the inner surface of the water jacket. Falling short of

the dew point leads to condensation and the formation of acids and therefore to corrosion on the reaction space side of the water jacket.

5 It is also customary to provide gasification reactors with a pressureless water jacket outside the reactor pressure casing. In this case, the temperature of this water jacket may amount to a maximum of 100°C and there is a great risk of the formation of condensate on the inside of the pressure casing and therefore of corrosion. Special corrosion protection measures, such as coatings on the pressure casing, afford only partial success.

### SUMMARY OF THE INVENTION

The object of the invention is to provide both an apparatus and method which, while being simple and reliable to operate, protects the pressure casing of the gasification reactor against corrosion and, in all operating states, rules out the condensation of water in the reaction space of the reactor pressure vessel and therefore the formation of aggressive acids.

According to the invention, it is provided that the reaction space contour of the pressure vessel be delimited for the gasification process by a refractory lining within the reactor pressure casing and for cooling ducts to be mounted on the outside of the reactor pressure vessel casing in order to regulate its temperature, the pressure and temperature of which ducts can be set, irrespective of the pressure and temperature on the inside of the reactor pressure casing or in the reaction space.

The apparatus according to the invention is suitable for the gasification of ash-free or low-ash fuels, waste and residues, irrespective of their concentrations of water and acid-forming components, such as sulfur or halogens, and their consistency.

The invention provides apparatus in the form of a gasification reactor vessel and includes a pressure shell, which pressure shell has an encircling body wall and shell ends at each of opposite ends of the body wall. The pressure shell has a reactor space which operates under pressures of between ambient pressure and 80 bar, said reactor space being delimited by a reaction space contour which has a refractory lining inside the pressure casing and is distinguished in that the temperature of the pressure casing can be regulated. The wall of the gasification reactor is built up from the outside inward, in such a way that ducts are arranged on the outside, the pressure shell or casing surrounding the reaction space further inward and a

refractory lining being present on the inside, different materials constituting the refractory lining. The refractory lining may consist of a plurality of layers, the material of which may consist of ceramic, Teflon (polytetrafluoroethylene) or the like.

5 The method of operating the pressure vessel requires that the ducts on the outside of the pressure casing, an interior of which ducts is in communication with an outer surface of the pressure shell, consist of pairs of webs fixed at common edges as by welding to the shell body outer surface and which are closed by means of semicircular or arcuate segments. Water which serves for cooling the pressure casing is conducted through the ducts.

10 Further, in operating the reactor vessel and its cooling wall, it is required that the temperature in the pressure shell be regulated in such a way that it is more than 5 degrees Celsius above the dew point of the gas atmosphere present in the reactor space of the gasification reactor vessel.

It is advantageous, furthermore, that the ducts for regulating the temperature of the pressure casing are operated above or below the boiling point of the coolant.

15 The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of the disclosure. For a better understanding of the invention, its operating advantages, and specific objects attained by its use, reference should be had to the drawing and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

20 Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of

illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not necessarily drawn to scale and that, unless otherwise indicated, they are merely intended to conceptually illustrate the structures and procedures described herein.

**BRIEF DESCRIPTION OF THE DRAWINGS**

In the drawings:

Fig. 1 is a half section showing through the reactor;

Fig. 2 is a sectional view taken on the line A-A in Fig. 1; and

Fig. 3 is a side view of the reactor equipped with oblique or spiral arranged

ducts.



## **DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS**

Fig. 1 shows a longitudinal section and Fig. 2 a cross section through the gasification reactor vessel. The conversion of the fuels, residues and waste into a H<sub>2</sub>-rich and CO-rich crude gas by means of the oxygen-containing oxidizing agent takes place in the reaction space 1. The gasifying media are supplied via special burners which are fastened to the burner flange 2. Via the crude-gas outlet 3, which is provided with a special apparatus, the crude gasification gas leaves the reaction space 1, if appropriate together with a small fraction of liquid slag, and passes on for further gas treatment. The gasification reactor 1 is encased by the pressure shell or casing 4 which absorbs the differential pressure between the reactor interior and the outside atmosphere. For the thermal protection of said pressure casing, a refractory lining 6, 7, which can consist of the concentric layers 6 and 7 or else of a plurality of layers, is mounted on the inside. Outside the pressure casing 4 are arranged water-carrying ducts 5, e.g., extending longitudinally of the shell body wall and which are operated at pressures and temperatures independent of the pressure and temperature in the reaction space 1.

Consequently, both cooling of the pressure casing 4 during normal operation and heating, for example in the start-up mode, are possible. Furthermore, the pressure and temperature in the ducts 5 can be regulated in such a way that the temperature of the water does not fall short of the dew points on the inside of the pressure casing 4 and therefore no condensation occurs. The ducts 5 have an annular water supply 8 and an annular water discharge 9. The ducts 5 completely surround or encircle the pressure casing 4 and consist of webs which are welded onto the pressure casing 4 and are closed off by means of semicircular or arcuate segments 11. These arcuate segments 11 may be next to one another, wherein the ducts

are in abutment as shown on the right side of Figure 2. However, circular spacing may also be arranged between the ducts, the adjacent segments 11 then being arrayed as shown on the left side of Figure 2.

In a further exemplary embodiment, water is supplied to the reaction space 1 according to Figure 1 due to the moisture content of the fuels, residues or waste. Likewise, for example, steam is added to the reaction space 1 as an atomizing agent or as a moderator for the gasification reaction. As a result of the thermodynamic equilibrium of the gasification reactions, a defined steam content of the gasification gas is established, which condenses when it falls short of the saturation temperature. This condensed steam releases acid constituents from the gas atmosphere, such as halogen acids, sulfuric acids or hydrocyanic acid, and therefore has an extremely corrosive effect. In order to prevent steam from condensing on the pressure casing 4, thus leading to destruction by corrosion, its wall inclined toward the gasification space must have a higher temperature than would correspond to the dew point. If the reactor pressure is, for example, 30 bar and the steam content of the gas 50% by volume, the steam partial pressure is 15 bar.

According to the steam pressure curve of the water, the boiling or dew point is 198°C. If the temperature of the pressure casing 4 is below 198°C, steam impinging onto it condenses into water, with the consequences indicated. If the temperature of the pressure casing 4 is higher than 198°C, for example by 5°C, steam impinging onto it cannot condense. By modifications to the water content of the gasification substances and during start-up and run-down processes, widely different steam contents in the gasification gas and therefore dew points

can be established. Thus, by the temperature of the pressure casing 4 being regulated, there is the possibility of avoiding a shortfall of the dew point.

The pressure in the reaction space 1 according to Examples 1 and 2 in relation to the outside atmosphere is absorbed by the pressure casing 4. There is therefore the possibility of setting the pressure in the ducts 5, irrespective of the pressure in the reaction space 1, in such a way that the pressure casing 4 acquires the desired temperature. The relation between pressure and temperature in the water-carrying ducts 5 is determined by the steam pressure curve of the water. The desired temperatures can be regulated by the pressure in the ducts 5 being fixed and by a preheating or cooling of the circulating water flowing through the ducts 5. At the same time, in a desired way, the liquid can remain liquid or boil, depending on the setting of the temperature and pressure in the ducts 5.

Vertically or obliquely arranged, e.g., spiral course ducts 5 between the water supply 8 and water discharge 9 are shown in Figure 3.

The invention is not limited by the embodiments described above which are presented as examples only but can be modified in various ways within the scope of protection defined by the appended patent claims.

Thus, while there have shown and described and pointed out fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in

substantially the same way to achieve the same results are within the scope of the invention.

Moreover, it should be recognized that structures and/or elements and/or method steps shown and/or described in connection with any disclosed form or embodiment of the invention may be incorporated in any other disclosed or described or suggested form or embodiment as a general

5 matter of design choice. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.